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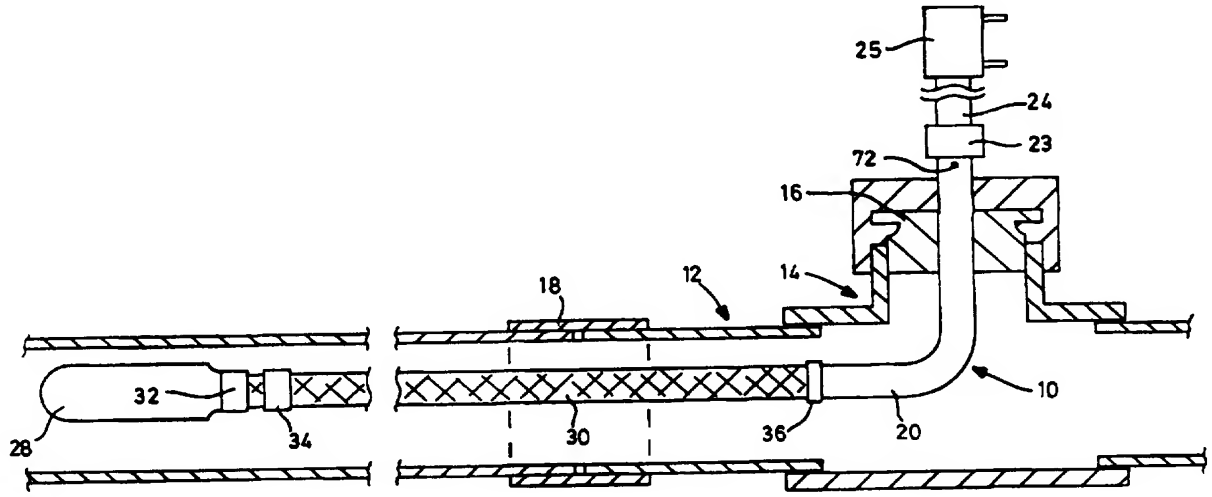

(57) Abstract

A heating cable has a self-regulating element which is sealed at one end. A boot is placed over the sealed end and secured by swaged rings to the element. A protective sheath extends along and over the element and is secured to the element at spaced locations. An indicating strip is interposed between the cover and conductor to provide a visible indication of an adverse physical condition, such as ingress of water. The element is connected to a power cord by a splice which is vented to the exterior of the element adjacent the splice.

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CABLE WITH BOOT AND INDICATOR

The present invention relates to electrical cables for use in damp or wet environments. Electrical cables are used in a variety of applications in which they may be in contact with water. One such application is a heater cable which is used to inhibit freezing or maintaining a temperature in fluid supply lines.

The freezing of fluid in a supply line, such as a water supply line, is a constant problem, particularly in areas of harsh climatic conditions. To inhibit freezing, it is usual to bury the line below the expected frost line where possible. However, particularly harsh or prolonged low temperatures may still cause the temperature of fluid in the line to drop below the freezing point.

Similarly, in process control it is desirable to maintain a fluid at or above a predetermined temperature to facilitate fluid flow or maintain operating parameters.

In Canadian Patent No. 2,019,590, there is described a heating cable that may be included in the supply line and which permits the line to be insulated. The cable uses a self-regulating heating element that prevents overheating and eventual burnout of the cable as well as being economical in use.

This product has been widely accepted in areas where the supply line cannot be buried, such as at recreational properties, and where supply lines are conventionally used.

Many domestic installations that are able to bury the supply line utilize a metal (typically copper) pipe. When freezing of this pipe occurs, there is a significant risk of damage to the pipe as well as inconvenience to the home owner. Attempts may be made to thaw the pipe by passing an electrical current along the pipe. A welding machine transformer is used for this but the practice is dangerous and illegal in some areas due to the potential for electrocution.

The heating cable shown in the above Canadian Patent could be installed in the pipeline to provide safe and effective protection. However, there is a small risk that sharp edges or burrs left on the metal pipe during its installation might damage the cable as it is inserted within the pipe. Careful installation of the pipe would of course avoid such a problem but where the heating cable is to be inserted retroactively, it is difficult to ensure that such sharp edges do not exist.

It is also recognized that the outer sheathing of a cable may be damaged during installation or by mechanical injury or may deteriorate in use so that it is normal to protect the conductor through a control device such as a ground fault circuit interrupter (GFCI). While such devices protect the end user and the system from adverse conditions, such devices only indicate that a problem exists and do not indicate what that problem is. Usually this requires partial disassembly of the cable installation to ascertain the component at fault and even then it only locates an individual component rather than specifying the location of the fault.

However, when the cable is left for prolonged periods, such as over an entire winter, the failure of the heating cable may result in severe damage to property. As such, it is desirable to provide a cable in which the breach of the protective coating can be readily detected. Similar considerations apply to other types of cables where the integrity of the sheath is of paramount importance.

It is therefore an object of the present invention to provide a heating cable in which the above problems are obviated or mitigated.

According to one aspect of the present invention, there is provided a heating cable having an elongate self-regulating heating element, one end of which is sealed and the opposite end of which is adapted for connection to a power source. A boot extends over the

one end to overlap the sheath between said one location and said one end. The boot is secured to the element in the overlap. Preferably a flexible protective sheath extends over and along the element from the one end toward said other and is secured to the element at spaced locations, one of which is adjacent the one end.

Preferably the sheath is metallic and may be braided to provide the requisite flexibility. A stainless steel braid is preferred.

The boot is preferably a synthetic plastic. To facilitate heat transfer from the element through the boot, a gel is preferably inserted in the boot to provide a continuous heat transmission path.

According to a further aspect of the present invention, there is provided a cable having a translucent cover encompassing at least one conductor. An indicating layer is located between the cover and the conductor to provide a visible indication of an adverse physical condition with the cover.

By providing a translucent cover, any damage to the cover would be identified by a visible indication on the layer such as by a change of colour, and would therefore enable the failure of the cable to be predicted and remedial action taken. It may, for example, be feasible to inspect the cable periodically, for example once a season, by simply withdrawing the cable and checking for such visible indications. On the other hand, if a cable does fail, it can readily be checked while being withdrawn and the location of the fault identified quickly.

It will be appreciated that the conductor could be an electrical conductor or several such conductors or could be an optic fibre bundle. The indicating layer may be sensitive to a number of different physical conditions, such as ingress or water or localized overheating. Where the indicating layer is intended to detect ingress of water, the water-sensitive layer could

be a silicate, an encapsulated dye or anhydrous copper sulphate or any other suitable chemical that can be located within a cable to provide a visible indication.

The layer could be provided by impregnation of a paper web with a suitable chemical or could be impregnated into a helically-wound textile wrap applied to the conductors prior to encapsulation in the sheath. Alternatively, a powder dusting could be applied prior to encapsulation in the outer cover.

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings, in which

Figure 1 is a side view of a heater cable;

Figure 2 is a longitudinal section of the cable shown in Figure 1;

Figure 3 is a transverse section on the line 3-3 of Figure 2;

Figure 4 is a perspective view of a portion of a cable with portions thereof removed for clarity;

Figure 5 is a view on the line 5-5 of Figure 4;

Figure 6 is a side view of an alternative embodiment of cable;

Figure 7 is a section through a splice at VII-VII in Figure 1; and

Figure 8 is a detail view of a portion of Figure 7.

Referring therefore to Figure 1, a heating cable generally indicated at 10 is located within and extends along a water supply line 12. The supply line 12 is provided with a T-fitting 14 through which the cable 10 is inserted and sealed by means of a gland 16. The pipe 12 would typically be made of lengths of copper pipe interconnected by unions indicated at 18. The pipe 12 will extend from a main supply line into a house and more typically will be buried below the anticipated frost line where possible.

The heater cable 10 includes an elongate

heating element 20 of a self-regulating type such as that available from RAYCHEM under the trade name BTV Series or from Furon Dekoron under the trade name 2700 Series. The heating element 20 includes a pair of electrical conductors 22 which are interconnected by a conductive polymer core 44 (Figure 4) to provide resistive heating The heating effect is proportional to the difference between the ambient temperature and a set temperature so that the heating effect is self-regulating. Conductors 22 of the heating element 20 are connected at one end of the element 20 through a splice 23 to an electrical power cable 24 for connection to an electrical power supply through plug 25.

The opposite end 26 of the element 20 is sealed and, to protect the seal, covered by an elastomeric boot 28. The boot 28 is formed from a semi-rigid elastomer such as SANDOPRENE and is filled with a gel 29 which has dielectric or insulating properties such as a silicone gel. The gel 29 also provides lubrication for the boot as it is inserted over the end of the cable and also serves to fill any voids between the cable and the boot to provide a continuous transmission medium.

The boot 28 may be formed from other materials, such as fluoropolymers or thermoplastic elastomers. In general the material will be chosen to suit the environment in which the cable is used, such as temperature or the chemical in which it will sit or be in contact with. One particularly beneficial material for the boot 28 is VITON which is suitable for use in the hydrocarbon industry. Where the cable 10 is used with potable water, non-toxic thermoplastic elastomers may be used for the boot 28.

A metallic sheath 30 extends over the element from adjacent the end 26 toward the T-coupling 14. The metallic sheath 30 is preferably a braided stainless steel sheath having the requisite flexibility to allow installation of the cable and conformation with the pipe

12. The sheath 30 extends toward the end 26 but terminates prior to the end. The boot 28 overlaps the sheath 30 and a mechanical clamp 32 extends around the boot 28 to secure it to the element 20. The clamp 32 is a continuous metal annulus which is swaged into position. The diameter of the annulus is sufficiently large initially to be passed over the boot and its diameter may then be reduced by swaging so that the inner surface of the clamp 32 engages the boot 28 and secures it to the element 20. The stainless steel sheath 30 is mechanically trapped between the boot and the element 20 so as to be retained. The swaging is performed by a swaging tool which displaces material in the clamp 32 so that as it reduces the external diameter, the thickness of the annulus increases and applies a uniform pressure on the boot 28. The mechanical connection of the boot to the cable provides a positive retention of the boot even where the surface of the cable and/or boot is formed from materials that are difficult to bond, such as Teflon.

The metallic sheath 30 is itself secured directly to the element 20 by means of a similar clamping ring 34 located adjacent to the boot 28. The clamping ring 34 also has an internal surface which engages directly with the braid to force it into contact with the element 20. A similar clamping ring 36 is located at the opposite end of the sheath 30 adjacent the T-fitting and the clamps 34,36 inhibit recoil of the sheath so that the cable may be readily manipulated into the line 12.

As can be seen in Figures 4 and 5, the pair of electrical conductors 22 are encased in resistance grid 44 which has laterally extending resistance elements 46. The form of the grid 44 is well known and is utilized in heating cables available under the trade name RAYCHEM.

The grid 44 is encased in an insulating sheath 48 that electrically isolates the grid 44 but allows transmission of heat from the heating element 20 to the exterior of the cable 10.

The insulating sheath is encased in a ground braid 50 which is spirally wound and extends around the outer periphery of the sheath 48.

An outer jacket 52 encompasses the insulating sheath 48 and ground braid 50 and is formed from a translucent plastics material such as PVC or TEFCEL available from DuPont. The jacket 52 protects the electrical components of the element 20 against mechanical damage and the effect of adverse environmental conditions.

A pair of indicator strips 24 extends longitudinally of the element 20 between the ground braid 50 and the outer jacket 52. The indicating strips 54 are formed from a paper web impregnated with a moisture indicating material such as a silicate, an encapsulated dye, anhydrous copper sulphate or LEVCO dyes. The indicator material is selected so that a visible colour change occurs upon contact with water. In many applications, the strip will be printed with water soluble ink in concentration that will stain the paper upon contact with water. The colourant may also be selected for its ability to retain stain after the moisture is gone to provide a visible indication that moisture was present. Preferably the colourants will be chosen for their ability to bleed and stain while maintaining their intensity. The colourant may conveniently be applied to the web by a printing process or by application of dust, soaking or laminating. The colourant may vary in its properties such as materials that are phosphorescent, heat-sensitive. A phosphorescent strip may be used where black lighting will pick up water ingress in a dark installation, for example in locations in the Northern Arctic where low light level is experienced over an extended period.

The heater cable 10 is connected to the electrical lead 24 by the splice 23 shown in more detail in Figure 7 to prevent the migration of water to the plug

25.

As can be seen in Figure 7, the outer sleeve of cable 10 is removed to expose the conductors 22 and the ground braid 50 is gathered into a conductor. The conductors 22 and braid 50 are connected to corresponding leads of power cable 24 through barrel crimps 60 shown in greater detail in Figure 8. Each barrel crimp 60 has a pair of oppositely directed bores 62 that terminate in a solid central partition 64. The bores 62 receive respective conductors and the crimp 60 is then deformed to retain the conductors mechanically within the bores 62.

The crimps 60 are encased in a mastic 64 within a heat shrinkable sleeve 66 that extends slightly beyond the end of the crimp 60. The sleeve 66 is shrunk onto the crimp 60 once the conductors are secure to insulate the crimps 60 from one another.

The individual crimps 60 are encased in a mastic 68 that extends to the outer jackets of the conductors 10,24 and a heat shrink sleeve 70 positioned to overlap the outer jackets and encase the mastic.

A vent hole 72 is provided in the jacket 52 at a location just below the splice 23 but beyond the gland 16 so that a vent is provided across the jacket 52 to an ambient pressure zone.

The splice 23 inhibits the flow of water between the conductors 10,24 by providing a physical barrier with the mastic 64,68. The partition 64 in the crimps 60 also prevents transfer of water along the electrically connected conductors. Any water that enters a failure in the jacket 52 will migrate under the applied pressure of water in the pipe toward the splice 23. The physical barrier inhibits the further flow and the vent hole 72 provides a path to a relatively low pressure zone so that fluid water pressure is not continuously applied to the splice.

If preferred, the vent hole 72 may be replaced

with a capillary tube or a wick, such as a paper strip, extending between the heat shrink sleeve 70 and the jacket 52 to provide a vent path.

To install the cable 10, it is fed through the T-fitting and along the pipe 12. Typically the cable will extend up to 1,000 feet along the pipe 12. The boot 28 protects the sealed end 26 of element 20 as it is inserted and is sufficiently robust to resist accidental cutting from sharp edges or the like that may occur at the union 18. The outer surface of the heating element 20 is protected by the metallic sheath 30 against similar sharp edges as the cable is inserted.

Once the cable is deployed, the gland 16 is inserted into the T-fitting so as to seal the pipe 20 and the plug 25 connected to the power source. The gland is positioned so that the splice 23 is on the exterior of the pipe 20 with the vent hole 72 positioned above gland 16. The heater element 20 will then regulate the supply of current and the heating effect upon the water within the pipeline in accordance with the ambient temperature. Accordingly, if unexpected severe conditions and low temperatures are encountered, the heating cable 10 will inhibit freezing of the pipeline and therefore avoid the resultant inconvenience to the home owner.

In operation, the gel 29 within the boot 28 ensures transmission of the heat from the heating element 20 to the boot and also avoids localized heating that may cause premature failure of the heating element. The braided outer sheath 30 also ensures that water in the pipeline 12 is in contact with the heating element and that a continuous transmission surface is provided.

In the event that the outer jacket 52 is breached, the fluid contacts the indicator strips 54 which change colour. The outer jacket 52 is translucent so that a change of colour is immediately visible at the location of the breach. The change of colour will move along the strips 54 and be visible on the exterior of the

pipe between the gland 16 and splice 23. Periodic inspection will allow visible detection of the damage to the outer jacket 52 possibly before additional damage is done to the components of the cable 10. Alternatively, in the case of an immediate failure of the conductor 10, the indicator 54 will indicate the location of the damage so that the cable 10 may be repaired and put back into service. This is particularly useful where the cable is part of a network as the indicator strip 54 identifies the branch of the network where the cable is damaged.

It will be appreciated that the indicator strips 24 could be materials other than paper such as textile and any suitable indicator used that provides a visible indication of the ingress of fluid to the jacket 22.

The braided outer sheath 30 will of course obscure the indicating strip where it covers the outer jacket 52 but it will be effective to indicate a potential failure as it emerges from the gland 16. The cable 10 may then be withdrawn and the ring 36 released to allow retraction of the braid 30 and visual inspection of the cable for the location of the fault.

The stainless steel sheath and stainless steel clips provide a non-toxic surface that is compatible with the domestic water supply although brass or copper clips may be substituted if preferred.

Naturally the boots and rings may be made in different sizes to suit the cable and in different colours to signify different applications.

Although the cable has been described for use in a water pipe, it will be appreciated that the cable may be used externally of a pipe in applications where such cables are conventionally used. In such applications, the metallic sheath 30 may not be required but the mechanical connection of the boot 28 to the cable 10 provided by ring 32 ensures integrity of the seal at the exposed end of the cable.

An alternative arrangement is shown in Figure 6, where like components are indicated with like reference numerals with the suffix "a" added for clarity. In the arrangement of Figure 6, the indicator strip 54a is formed as a helically-wound braid impregnated with a suitable indicator and extending between the sheath 48a and the outer jacket 52a.

Although a simple change in colour of the indicator strip 54 is envisaged, the strip 54 could be printed with indicia such as a message of "caution and repair immediately" which would become visible upon impregnation with water.

The indicator strip 54 could also be made responsive to fluids other than water, such as diesel fuel, where the cable is to be used in a fluid other than water. The strip might also be made responsive to adverse physical conditions such as excessive temperature, to provide an indication of operating conditions to which the cable has been subjected.

The provision of the indicator strip 54 provides a visible indication of the location of the fault. By locating the strip 54 between the outer jacket 52 and the insulating sheath 48, an indication is provided before failure. Prolonged impregnation of water will tend to increase the area of the strip impregnated so that the longer the cable is left immersed in the fluid, the more visible the fault becomes. When used in a water supply pipe as shown in Canadian Application Serial No. 2,019,590, the indicator strip 54 will extend through the coupling to the exterior of the pipe so that a fault in the jacket 52 will eventually become visible at the exterior of the water pipe indicating that inspection is required.

At the same time, the venting of splice 23 and the physical barrier provided by the mastic and barrel crimps inhibits the spread of water to the conductor 24 and plug 25.

I claim:

1. A heating cable having an elongate self-regulating heating element, one end of which is sealed and the opposite end of which is adapted for connection to a power source, and a boot extending over said one end and in heat transmitting relationship therewith, said boot being secured to said element to inhibit ingress of water therein.

2. A heating cable according to claim 1 wherein a flexible elongate sheath extends over and along said element from said one end toward said other and is secured to said element at spaced locations.

3. A heating cable according to claim 2 wherein said sheath is interposed between said boot and said element adjacent said one end to provide an overlap therebetween and said boot is secured to said element at said overlap.

4. A heating cable according to claim 2 or 3 wherein said sheath is metallic.

5. A heating cable according to any preceding claim wherein said boot is connected to said element by a mechanical fastener extending circumferentially about said element.

6. A heating cable according to any preceding claim wherein a heat transmitting gel is inserted in said boot to occupy any voids between said boot and element.

7. A heating cable according to any preceding claim wherein said element is connected by a splice to a power cord for connection to said power source.

8. A heating cable according to claim 7 wherein a vent is provided at said splice to provide a communication between the interior and exterior of said splice.

9. A heating cable according to claim 8 wherein conductors in said element are connected to respective conductors in said power cord by mechanical connectors, said connectors having a partition interposed between adjacent ends of said conductors to inhibit flow of fluid therebetween.

10. A heating cable according to claim 9 wherein said mechanical connectors are insulated from one another and encompassed in a mastic body.

11. A heating cable according to claim 10 wherein said mastic is contained within a heat shrinkable sleeve that extends between said element and said power cord.

12. A heating cable according to claim 11 wherein said vent is disposed adjacent to but spaced from said sleeve.

13. A heating cable according to any preceding claim wherein said element includes a translucent cover and a conducting core and an indicator is located between said cover and said core and extending along said element, said strip being responsive to an adverse physical condition to provide a visible indication thereof through said cover.

14. A heating cable according to claim 13 wherein said indicator is a strip impregnated with a material responsive to said adverse physical condition.

15. A heating cable according to claim 14 wherein said strip is a paper web.

16. A cable having a conductor, a translucent cover encompassing said conductor and an indicator interposed between said cover and said conductor and extending along said cable, said indicator being responsive to a predetermined physical condition to provide a visible indication thereof through said cover.

17. A cable according to claim 16 wherein said indicator is a strip impregnated with a chemical responsive to said predetermined physical condition.

18. A cable according to claim 17 wherein said strip is a paper web.

19. A cable according to any one of claims 16 to 18 wherein said indicator is responsive to a contact with a fluid.

20. A cable according to claim 19 wherein said indicator changes colour upon contact with said fluid.

21. A cable according to claim 19 or 20 wherein said fluid is water.

22. A cable according to claim 21 wherein said indicator is a web impregnated with a moisture indicating material.

23. A cable according to claim 22 wherein said moisture indicating material is selected from the group comprising water soluble dyes, silicates, inks and anhydrous copper sulphates.

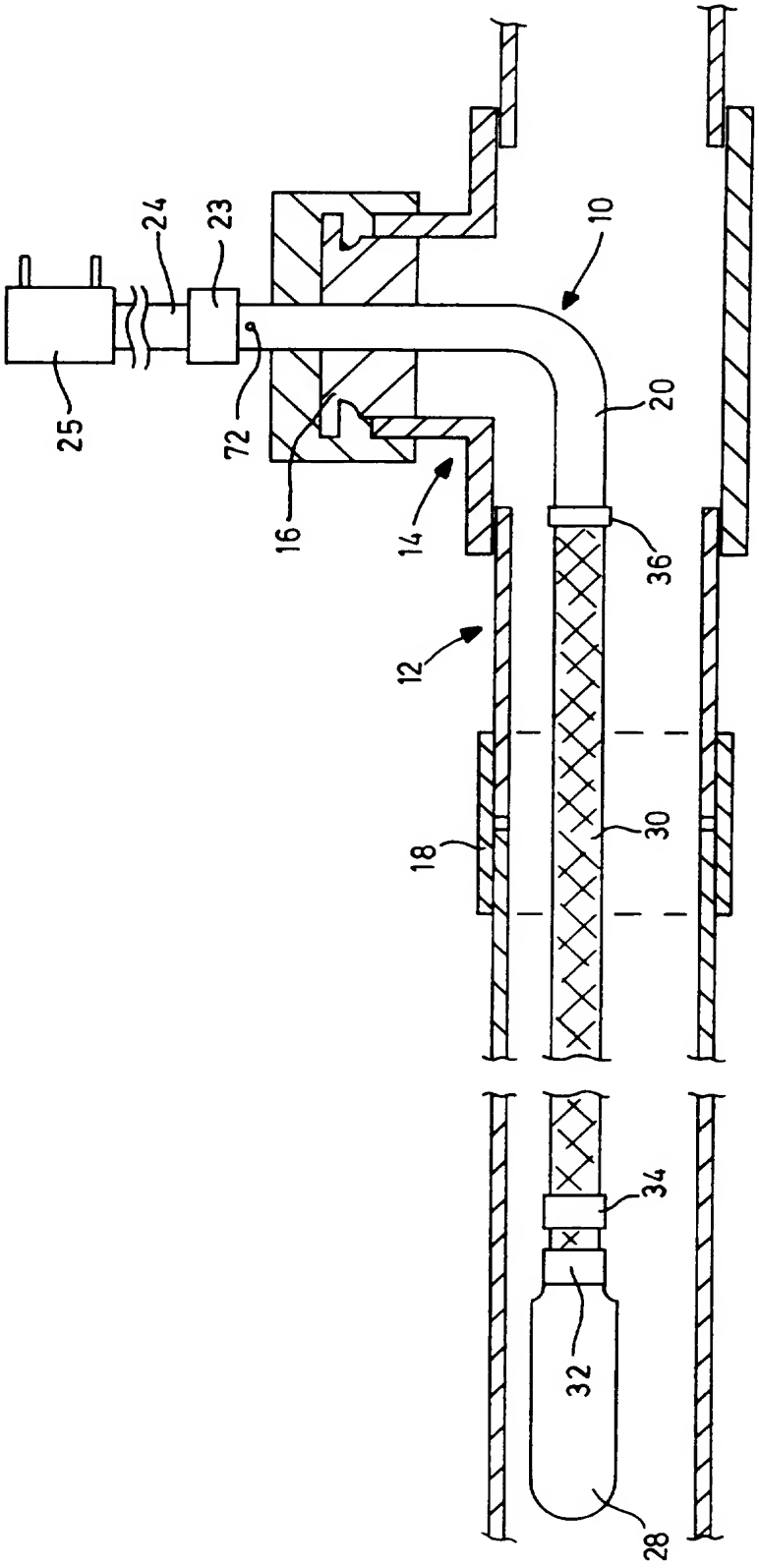

FIG. 1

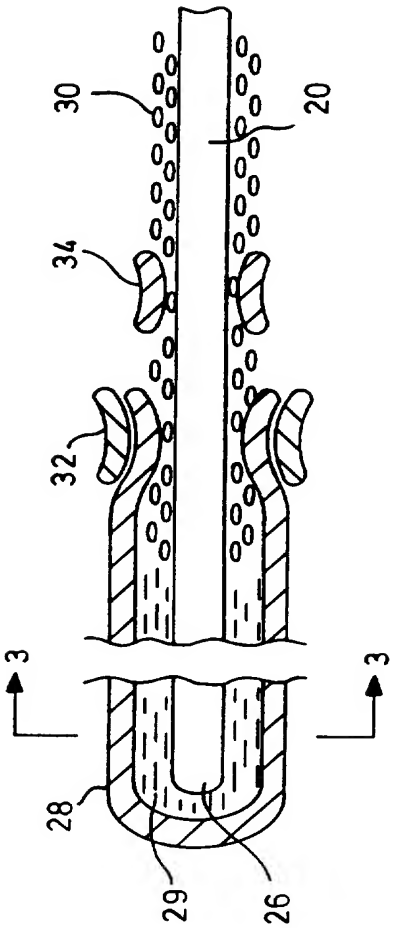

FIG 2

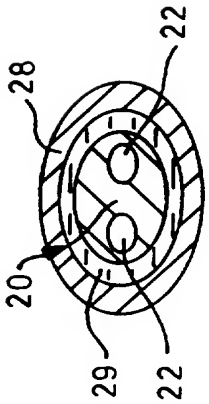

FIG. 3

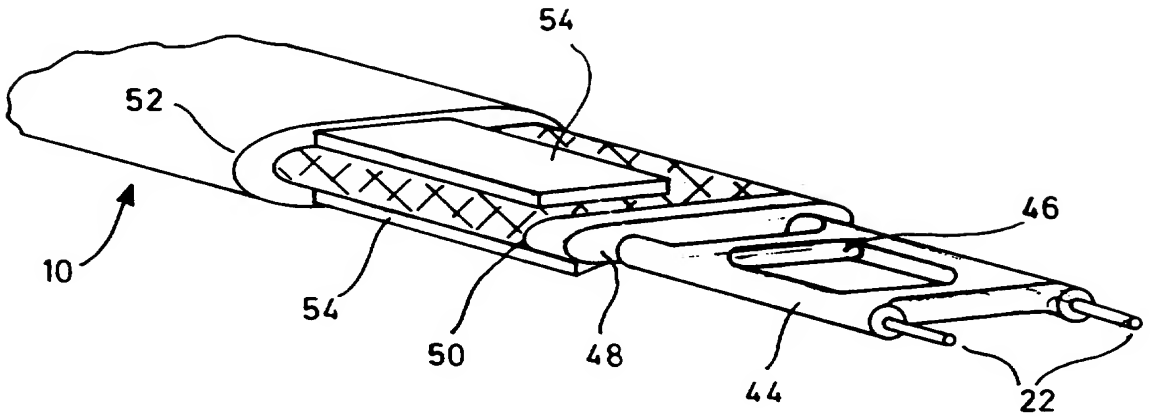

FIG. 4

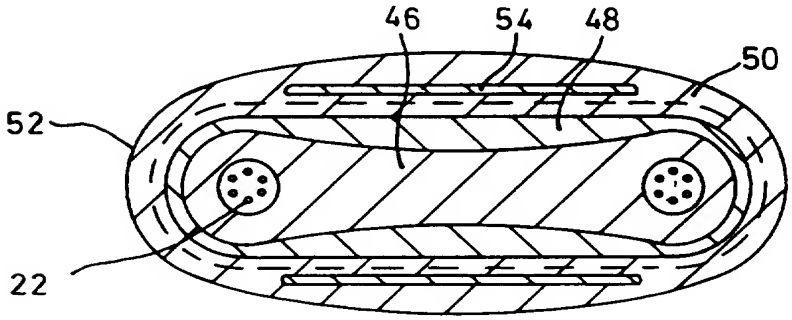

FIG. 5

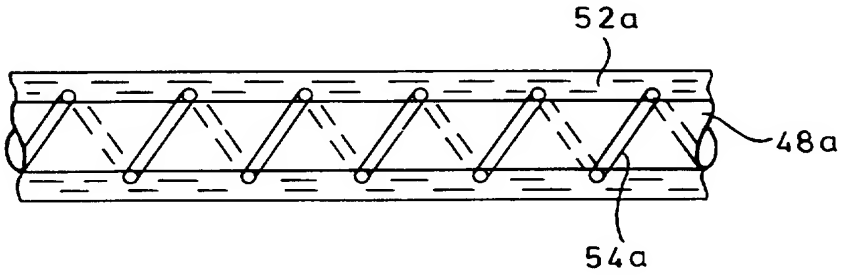

FIG. 6

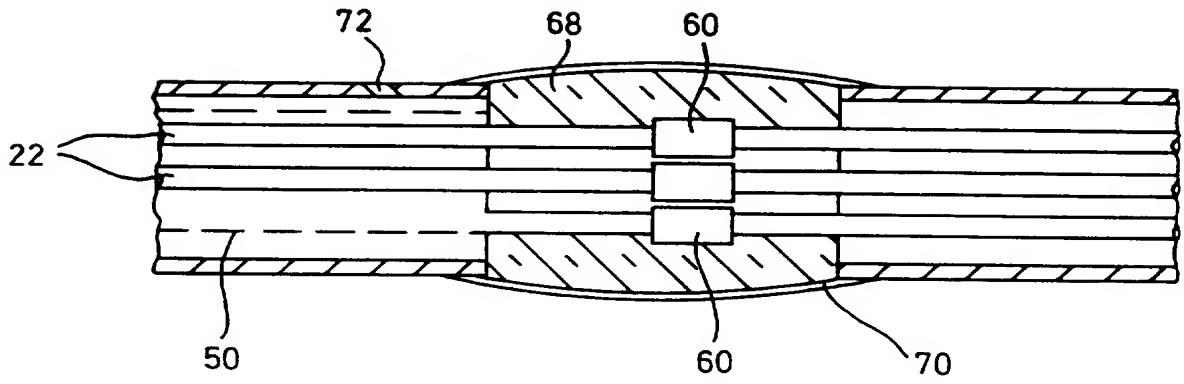

FIG. 7

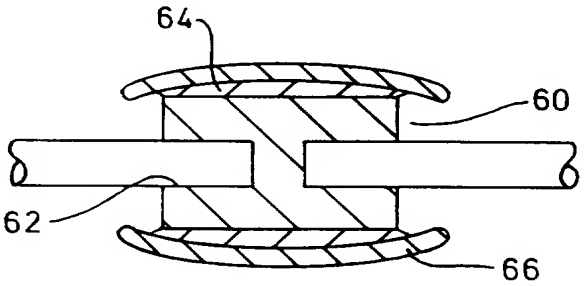

FIG. 8

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/CA 96/00258

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05B3/56 H02G15/04 H01B7/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05B H02G H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE,U,88 12 621 (HEMSTEDT GMBH) 24 November 1988 see the whole document ---	1,2,4
X	US,A,4 877 943 (OIWA THOMAS Y) 31 October 1989 see claims 1,11 ---	1,6
A	SE,A,107 251 (HERMES GMBH) 27 April 1943 see claim 1 ---	13,14, 19,20
A	US,A,3 590 139 (GILLEMOT GEORGE W ET AL) 29 June 1971 ---	
A	US,A,4 721 832 (TOY LESTER T) 26 January 1988 --- -/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 August 1996	06.09.96
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	**Authorized officer** De Smet, F

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